The Predictability of Lowland Snow in the Pacific Northwest

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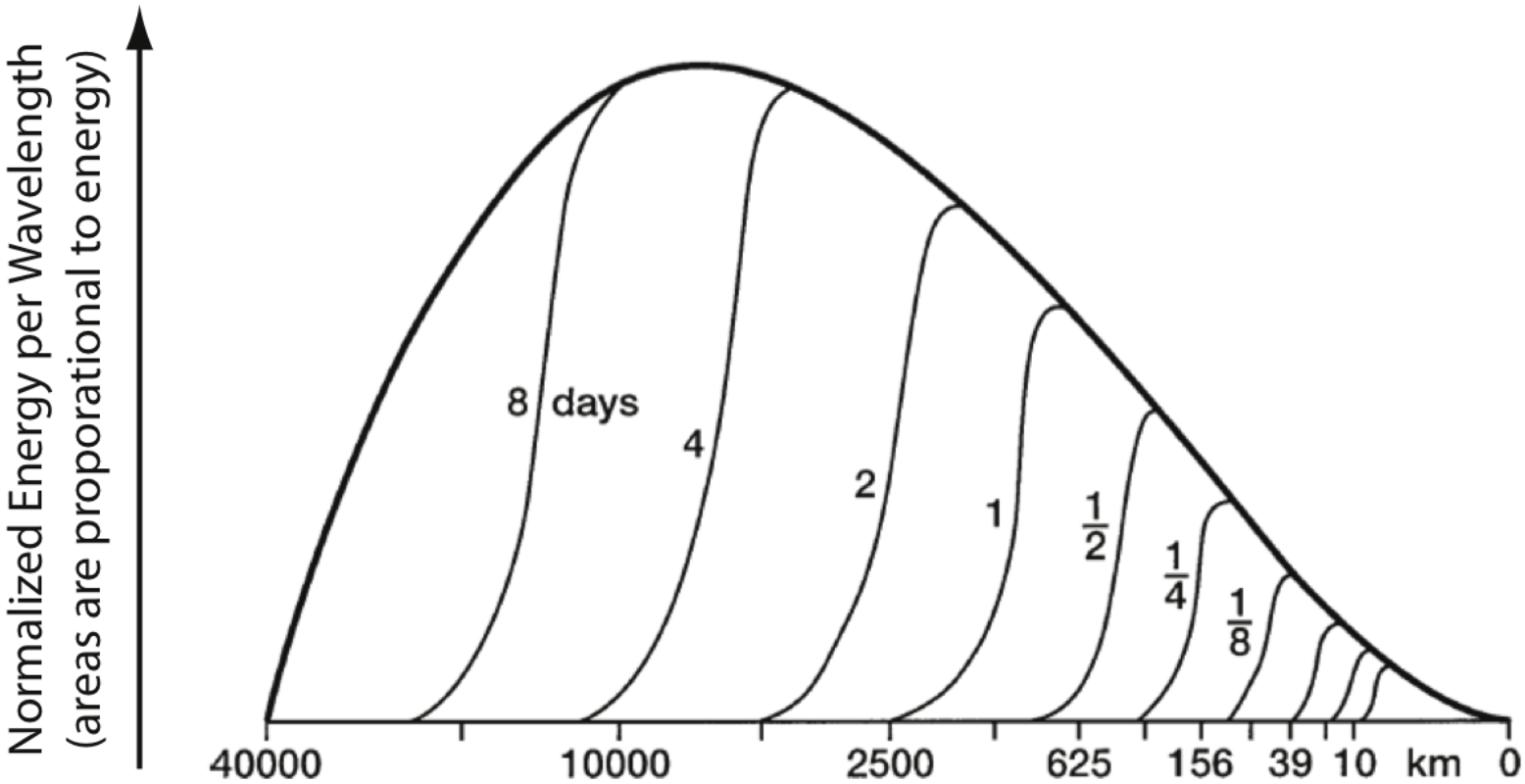
29 February 2012

Lorenz: Time for Errors to Propagate Upscale

1 hour to 20 km, 1 day to 1,250 km



Lorenz, 1969: The predictability of a flow which possesses many scales of motion. *Tellus*, **21,** 289-307.

The Question

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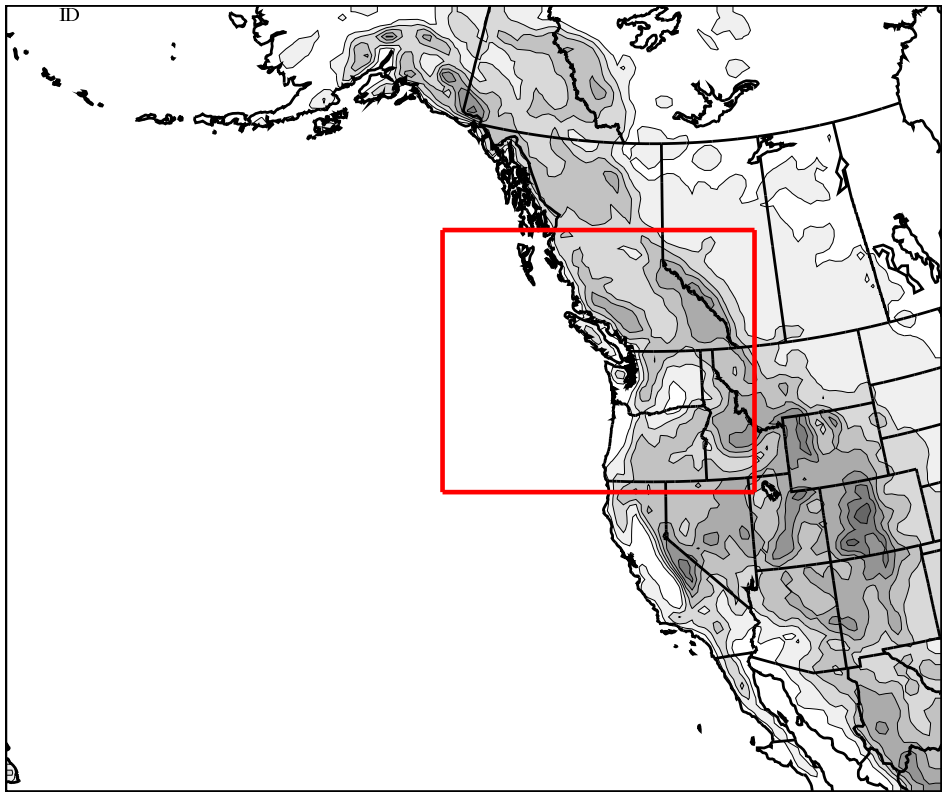
- Focus on the growth of initial perturbations.
- Ignore model errors

Ensemble Implementation

- Two cases from 2008:
  - 12-13 December
  - 17-18 December

COAMPS (1-way nest)



Δx =36- and 12-km

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- Developing short waves in NW flow.

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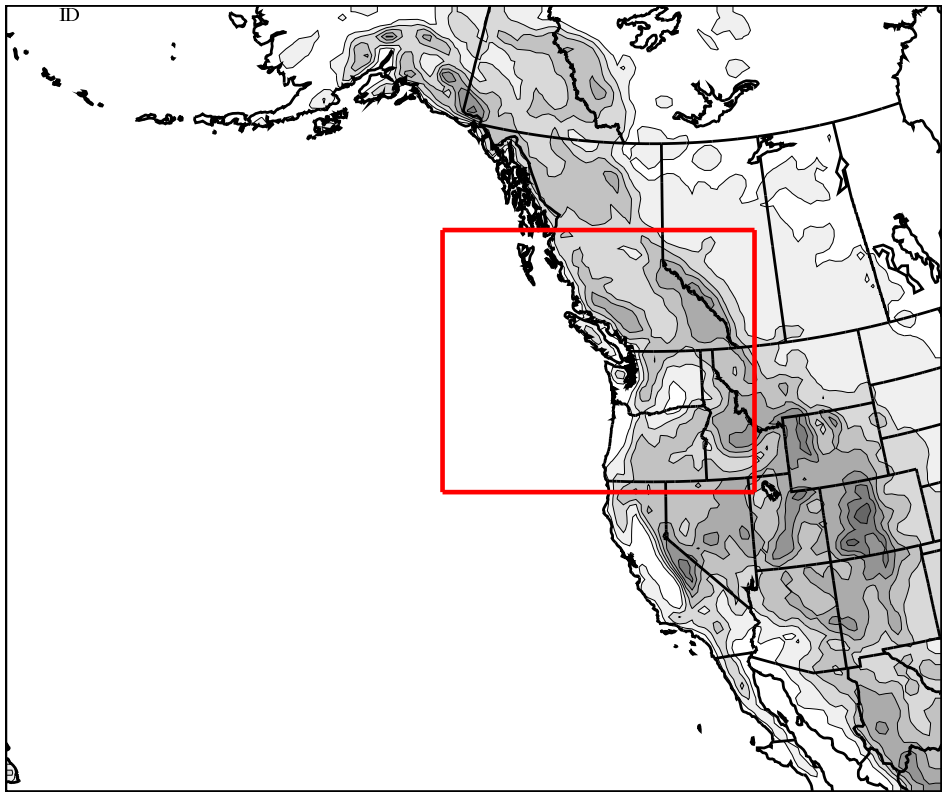

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Ensemble Implementation

- Two cases from 2008:
  - 12-13 December
  - 17-18 December
- Developing short waves in NW flow.
- 100-member EnKF ensemble

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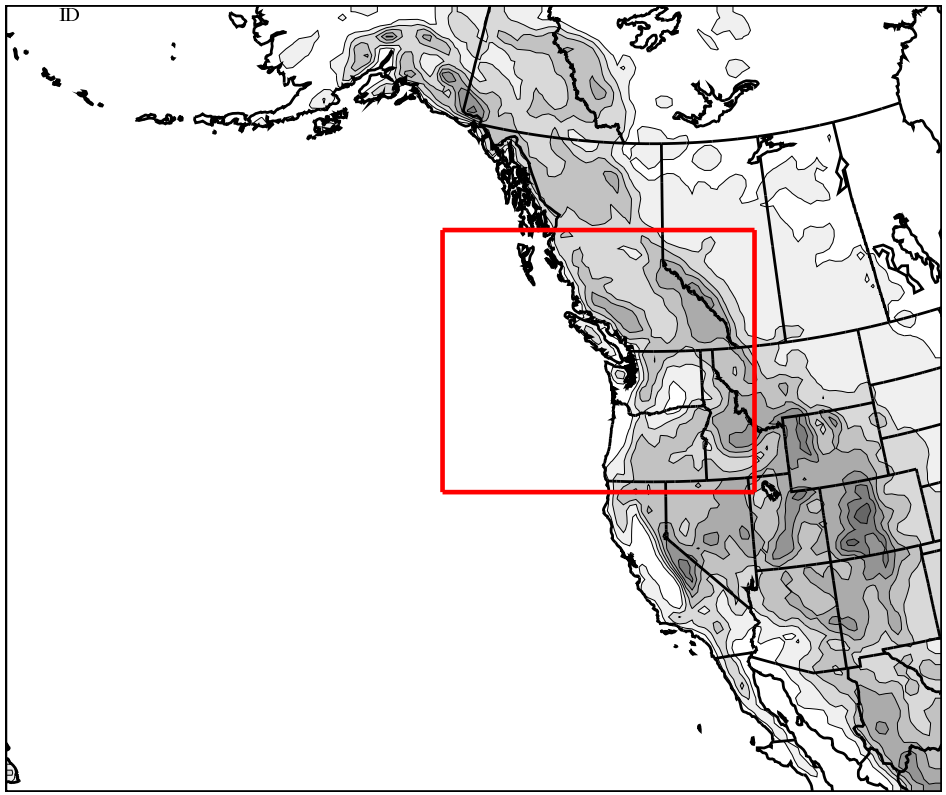

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Avoiding Details of the Model Parameterizations

Characterize the likelihood of snow by the:

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†Ferber et al., 1993: Snowstorms over the Puget Sound Low-Lands *Wea. Forecasting*

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Characterize the likelihood of snow by the:

- Presence of precipitation.
- 850-mb temperature: “Sharp rain-snow transition between about -4°and -8°C”† *(4° spread)*
- Sidestep sensitivities to
  - Ice microphysical parameterizations
  - Boundary layer parameterizations

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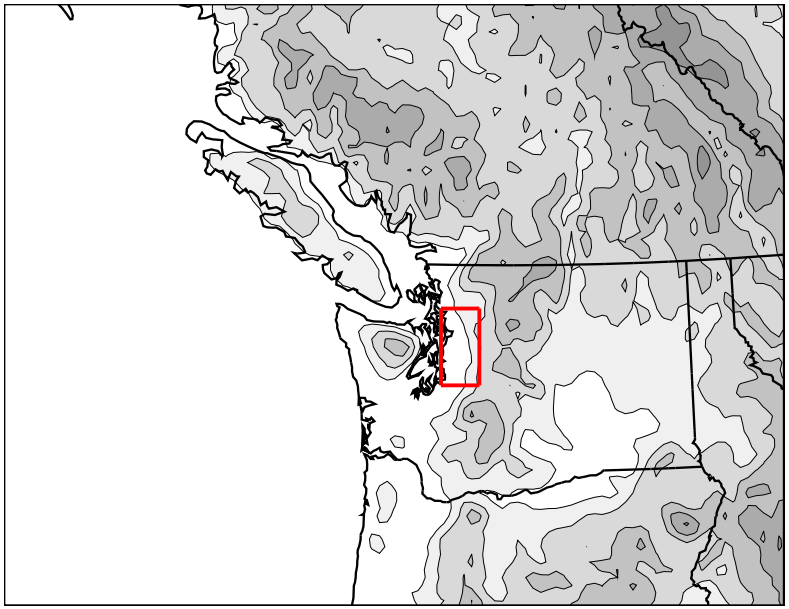
Ranking the Ensemble Members

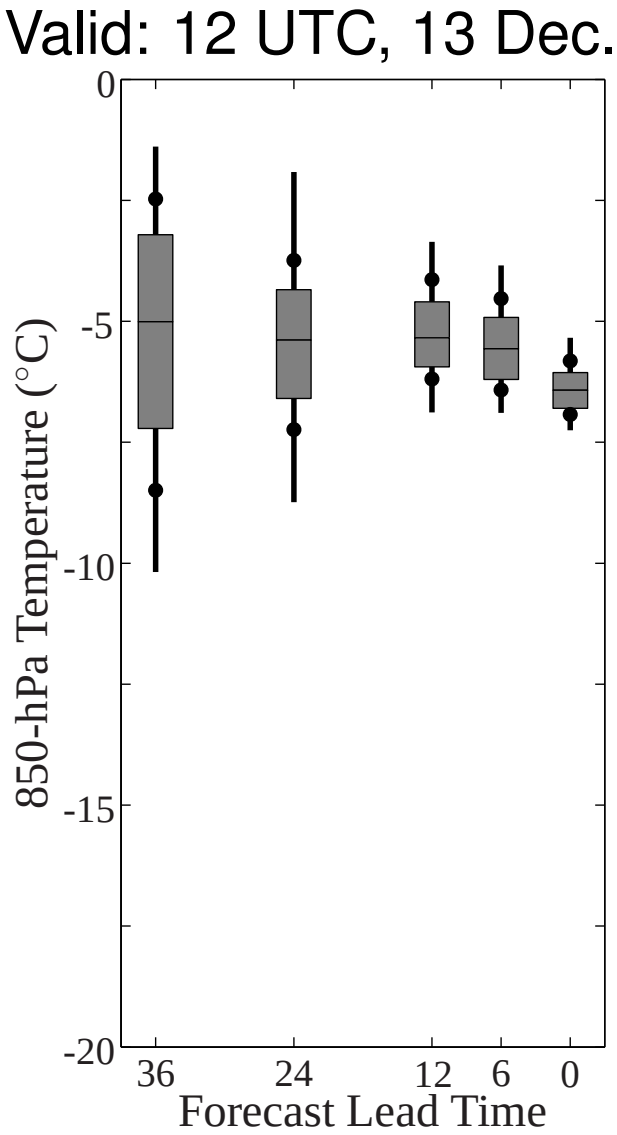


Rank by average 850-hPa temperature over red box at 12 UTC, 13 December 2008

- Warm sextile contains 17 warmest members
- Cold sextile contains 17 coldest

Temperature Metric at Various Lead Times

- Whiskers $\longrightarrow$ outer sextiles.
- Increased uncertainty with longer lead times.



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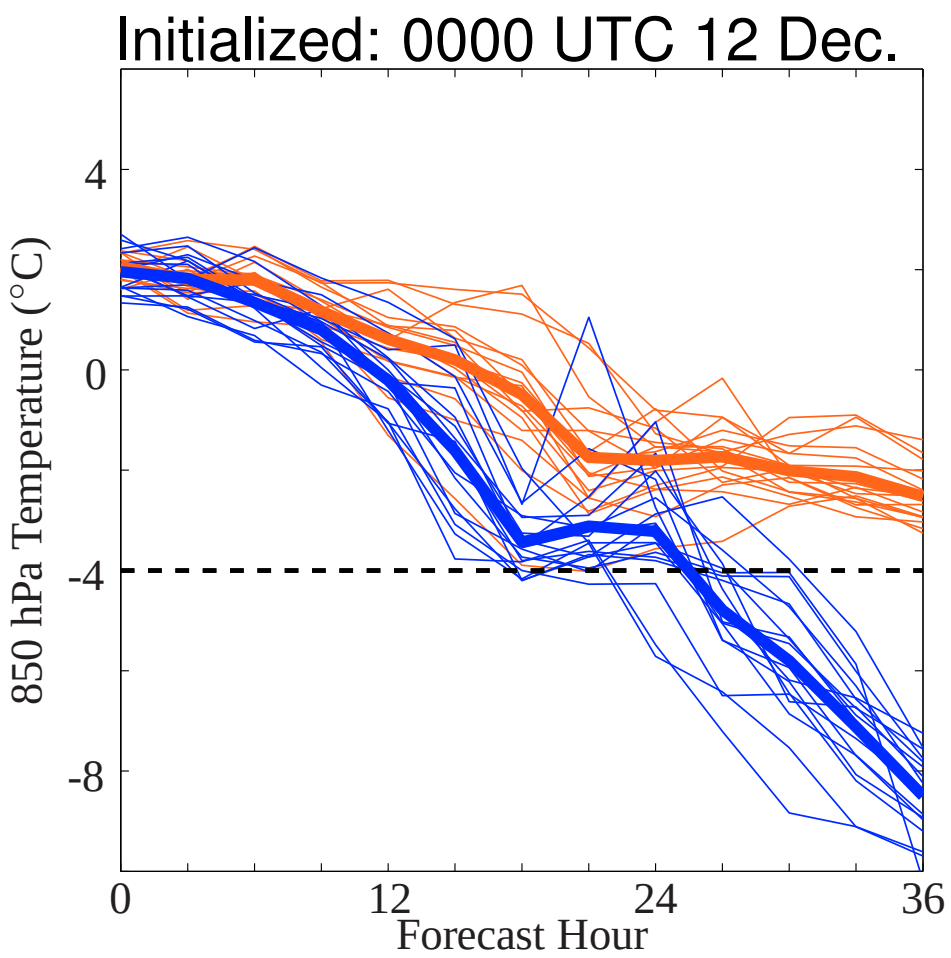
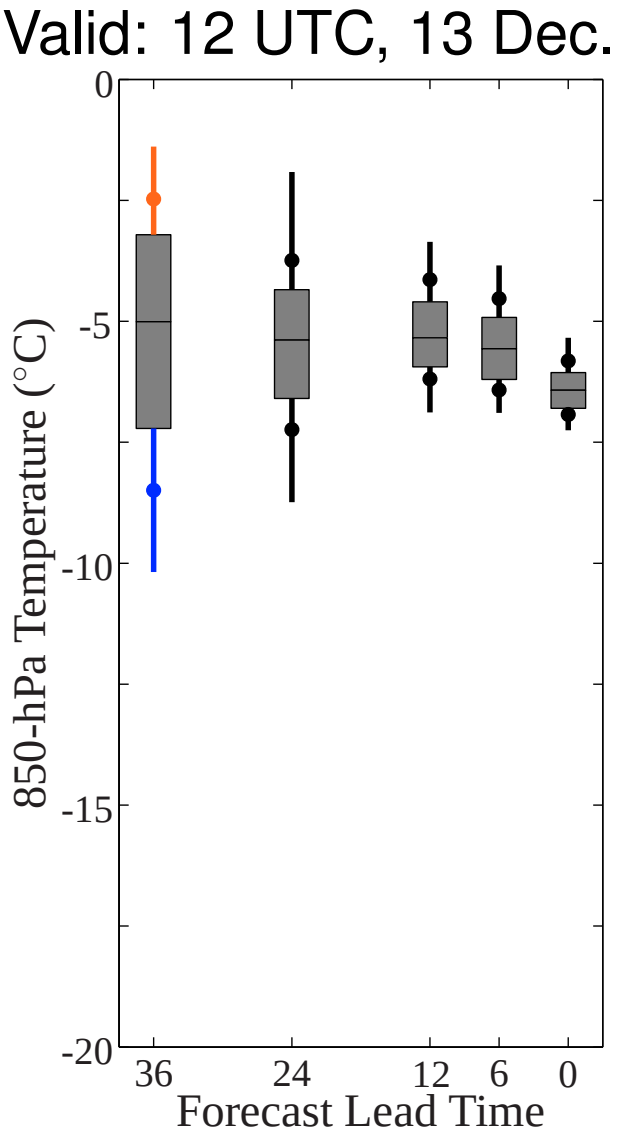
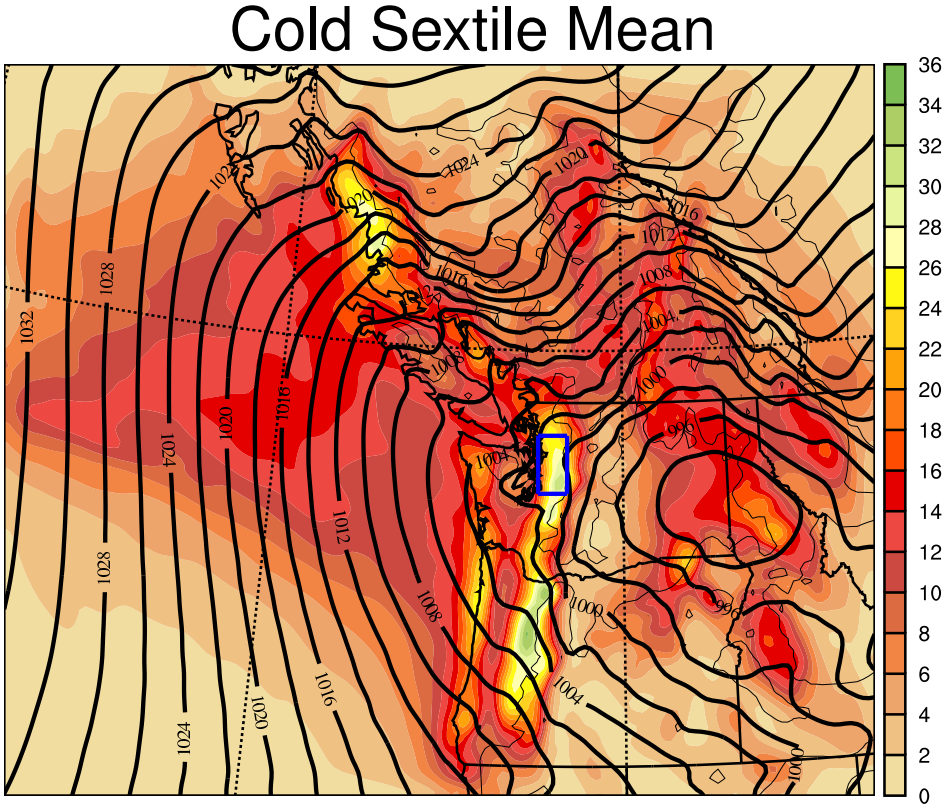
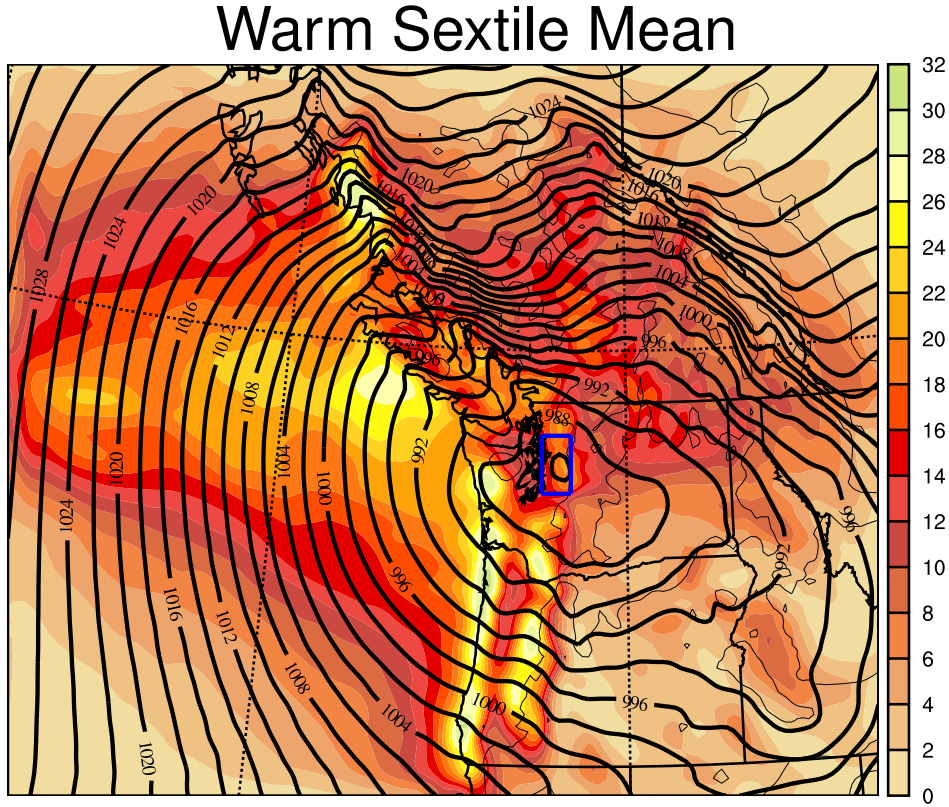


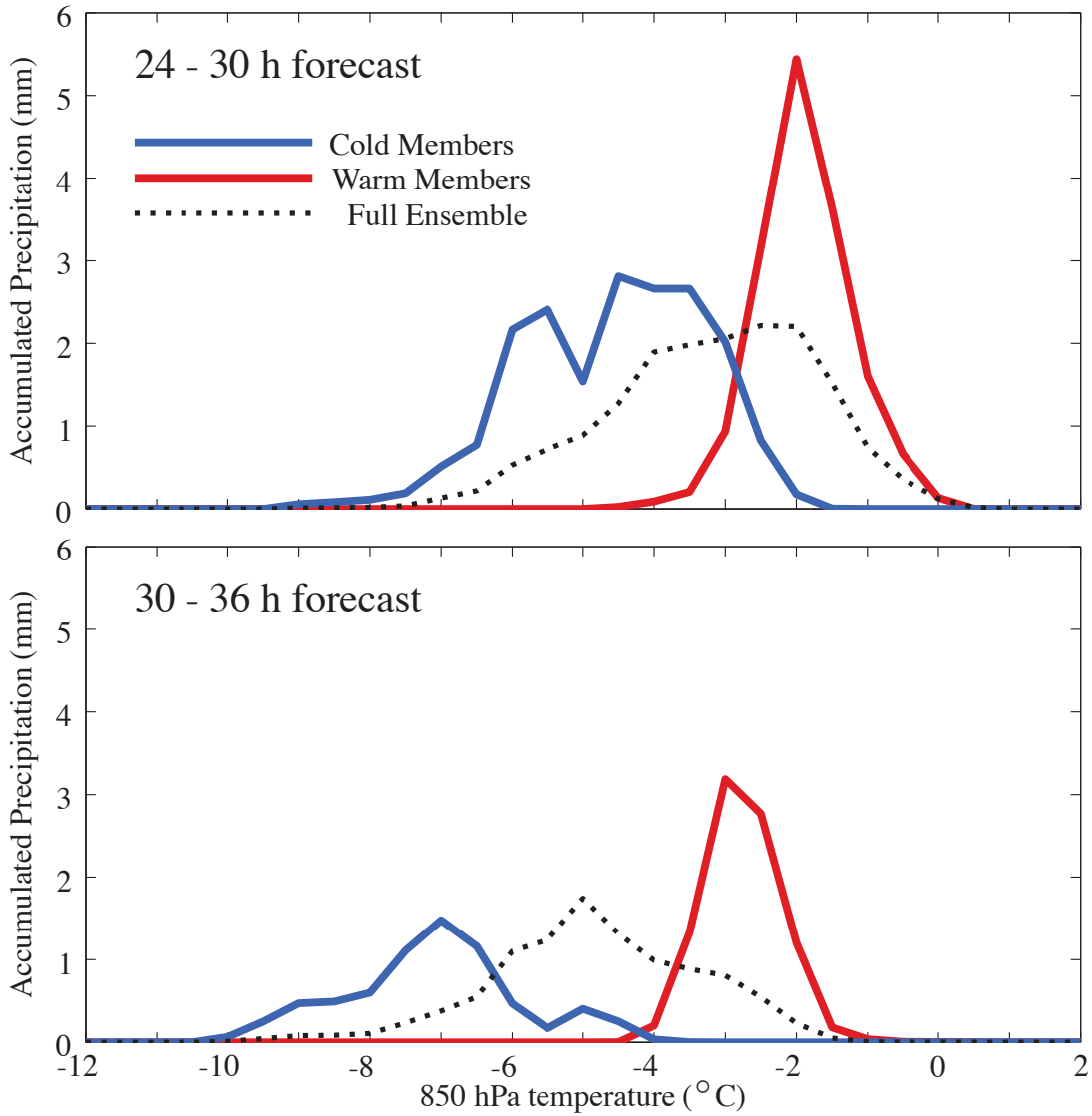


SLP and 24-hr Accumulated Precipitation





Temperature Weighted Precipitation



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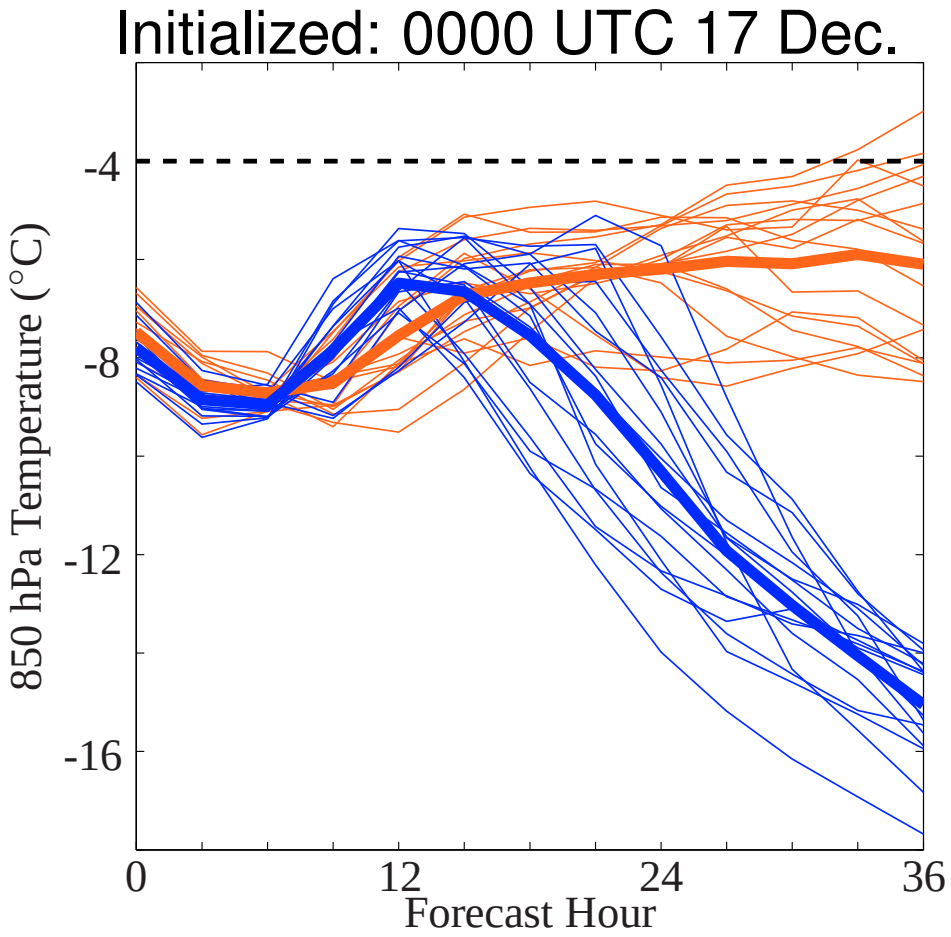
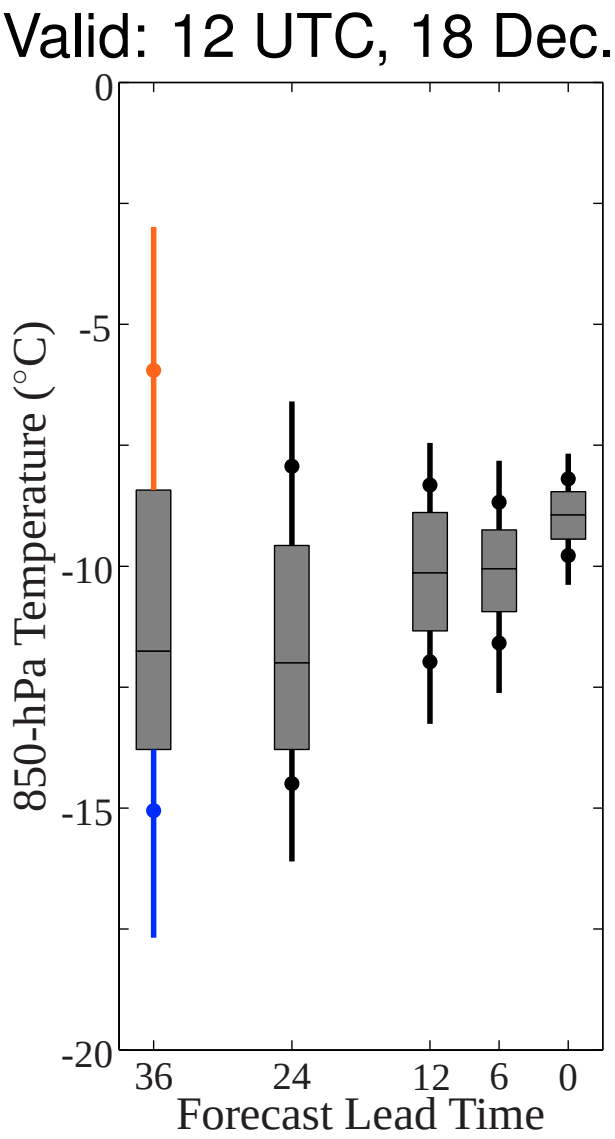
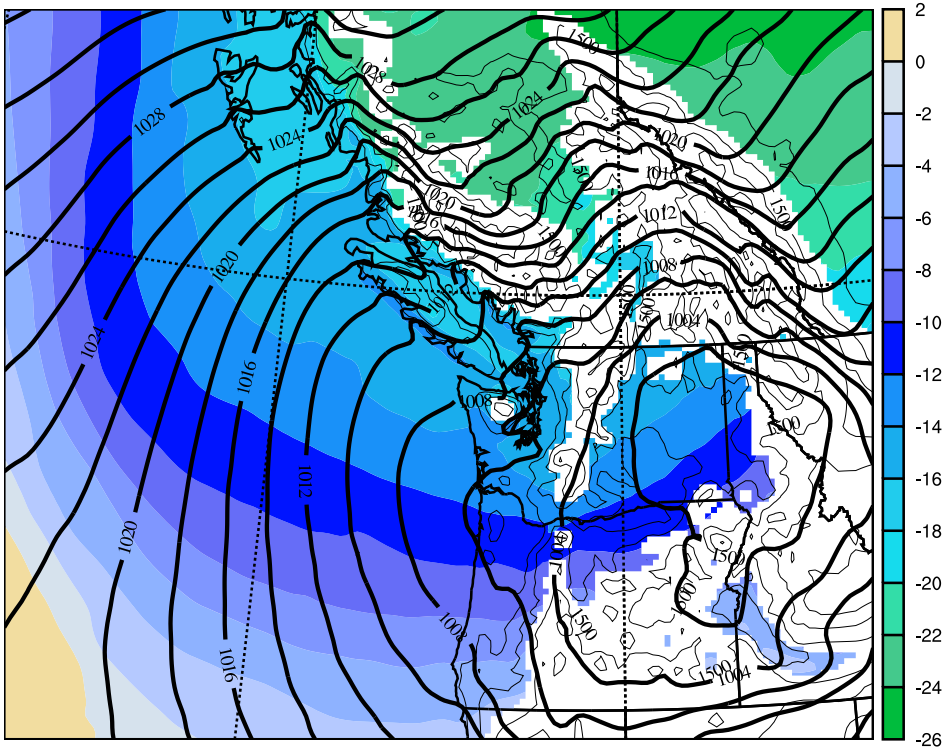


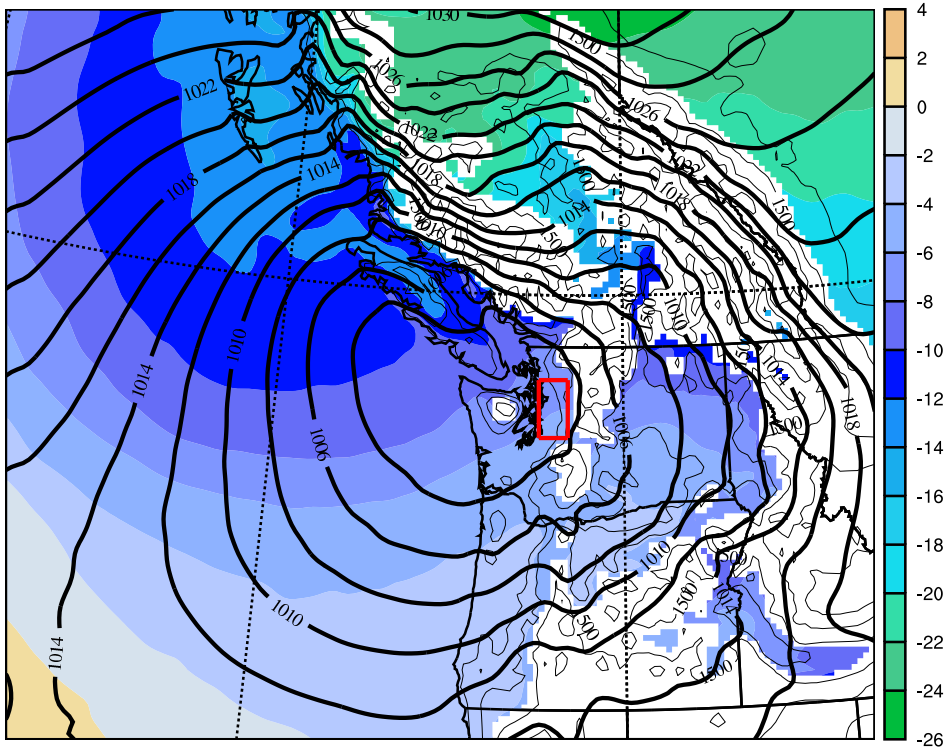


SLP and 850 hPa Temperature (36-hr Forecast)

Cold Sextile Mean



Warm Sextile Mean



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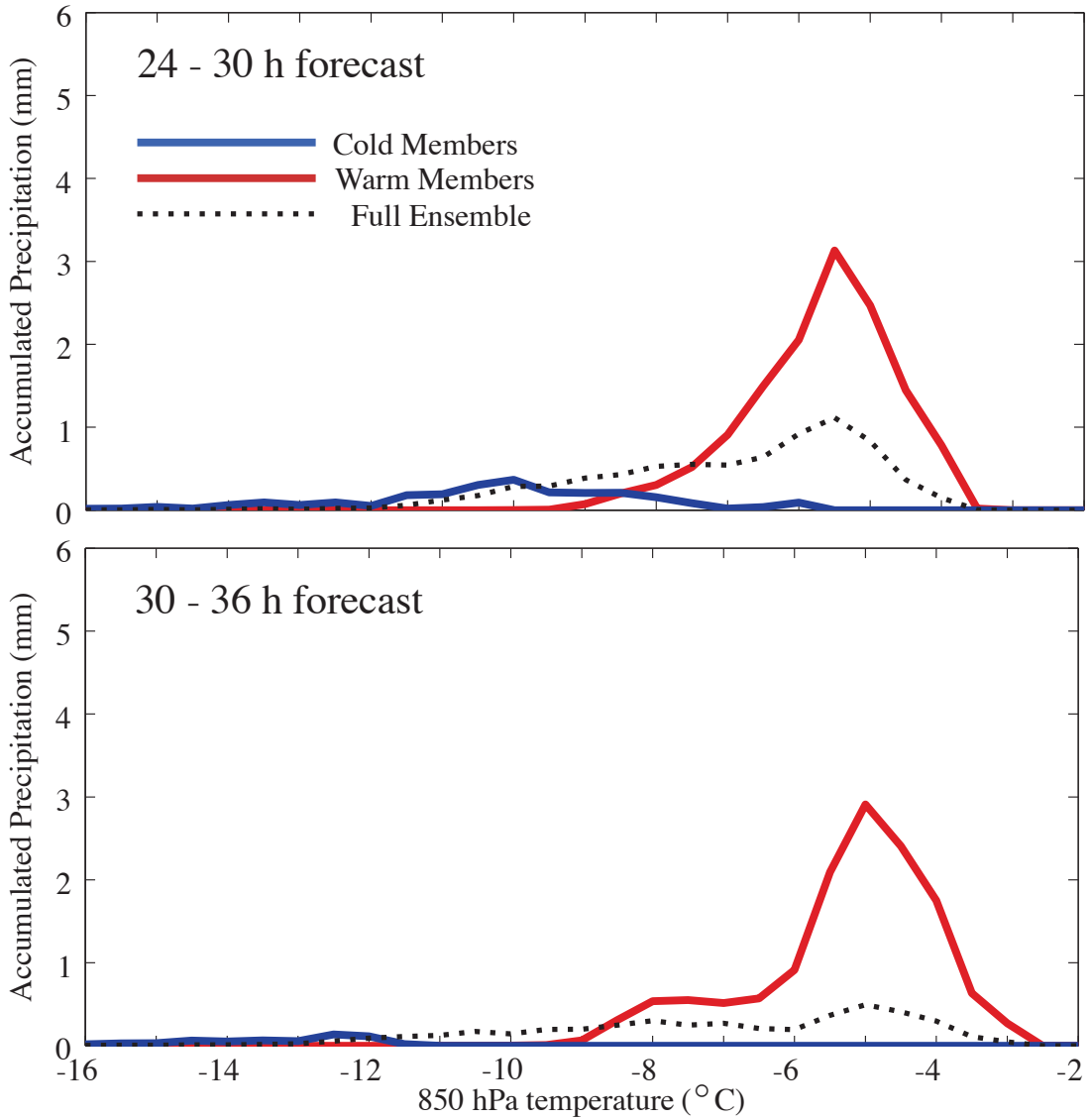

Summary

- Those ensemble members one-standard deviation away from the mean show large 850-mb temperature spread at it 36 hours
  - Climatological rain-snow transition over 4°C range.
  - *Case 1:* Range between cold and warm sextile means is 6°C.
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  - *Case 1:* Position of low centers differ by more than 400 km.
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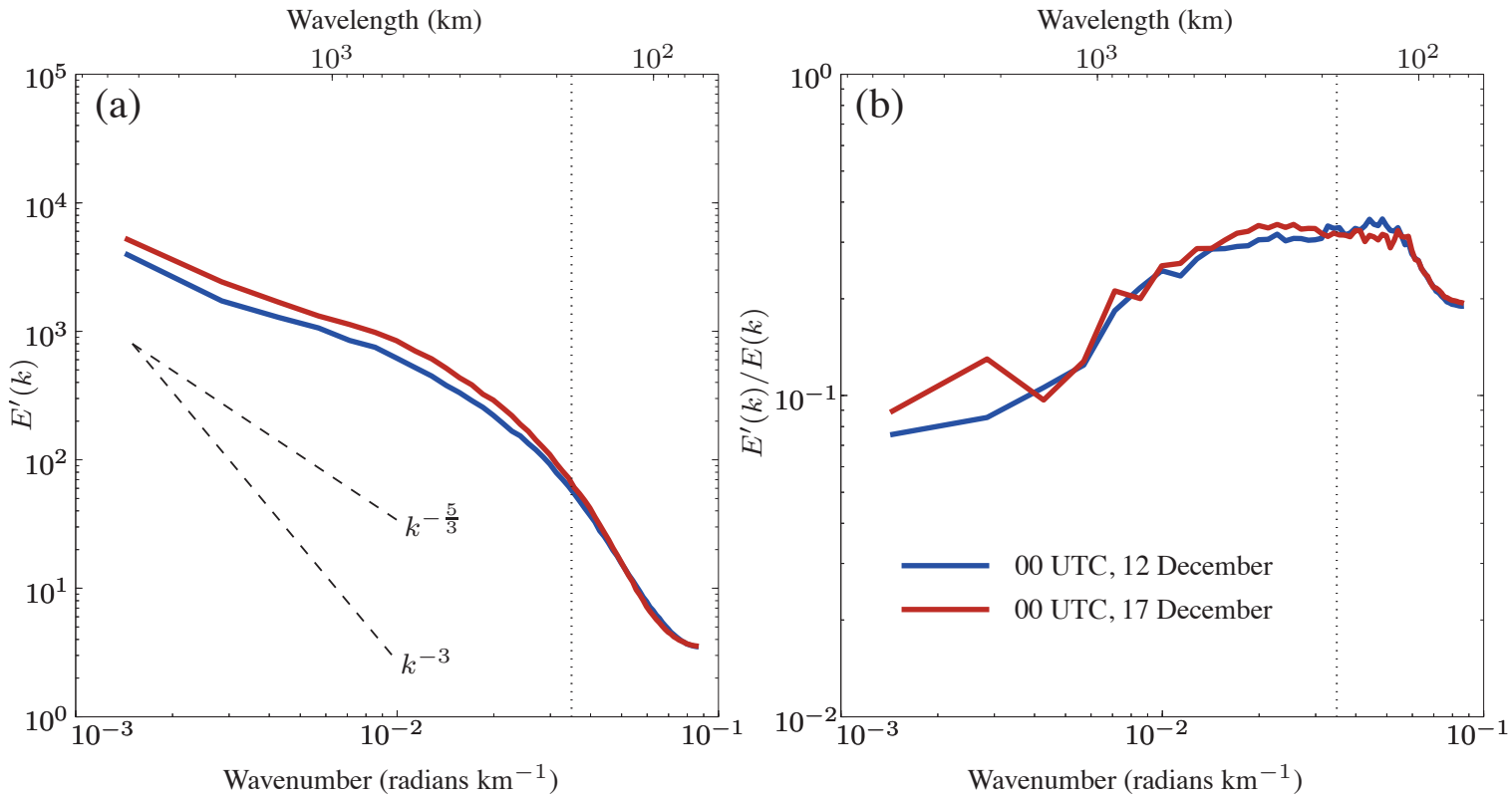
- Substantial differences in synoptic-scale pattern at 36 hours
  - *Case 1:* Position of low centers differ by more than 400 km.
  - *Case 2:* Position of low centers differ by more than 800 km.
- More pessimistic than Zhang et al., 2002, 2003
  - Significant differences in surface pressure pattern at 36 hours.
  - Error growth likely not dependent on moist convection.

Why does the error grow so fast?



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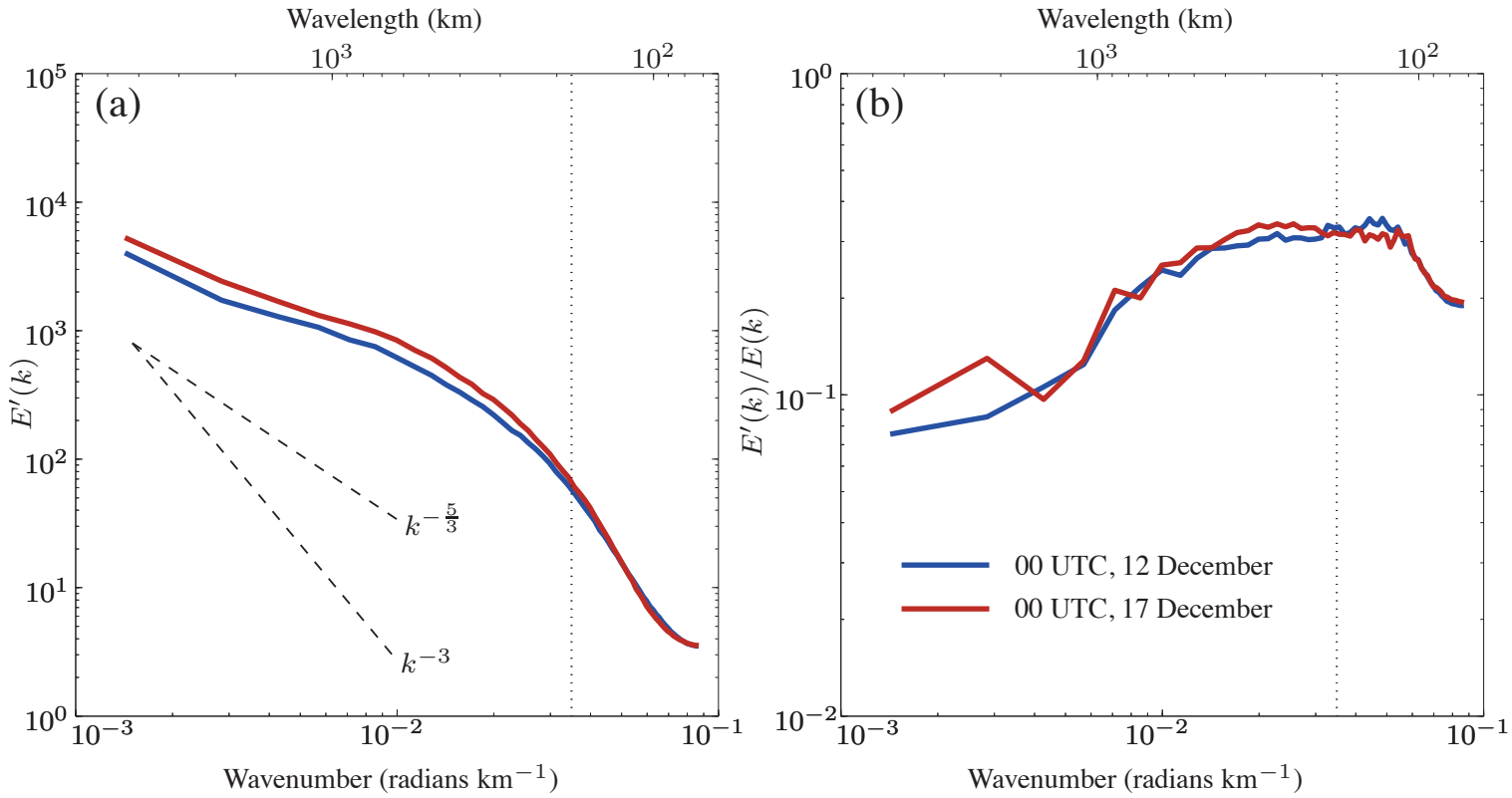

- Nontrivial initial errors at large scales.
- Downscale error growth is very rapid†

†Rotunno and Snyder: A Generalization of Lorenz's Model for the Predictability of Flows with Many Scales of Motion, *JAS*, 2008

Conclusion

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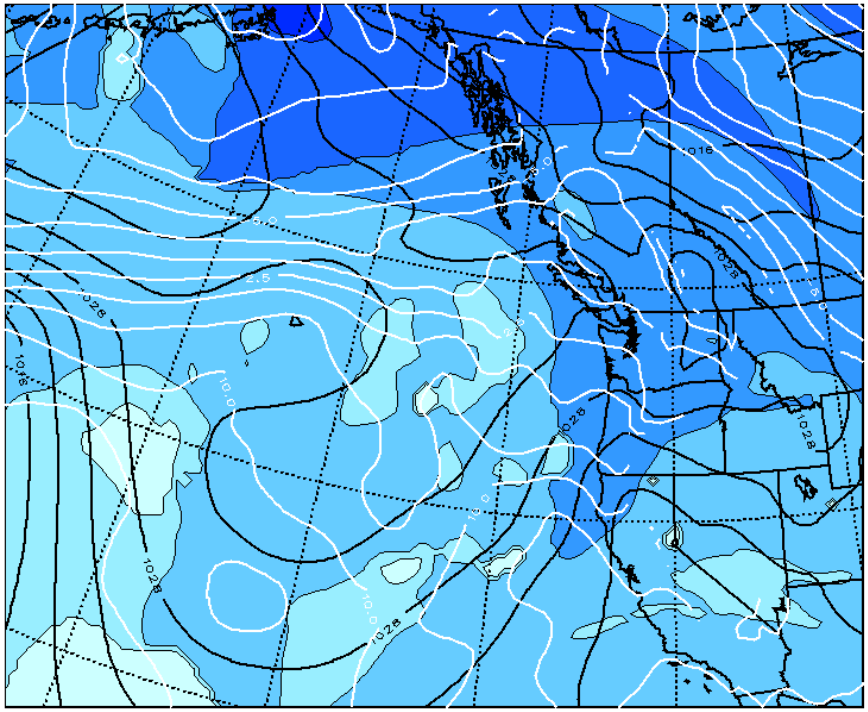
The large scale giveth and the large scale taketh away.

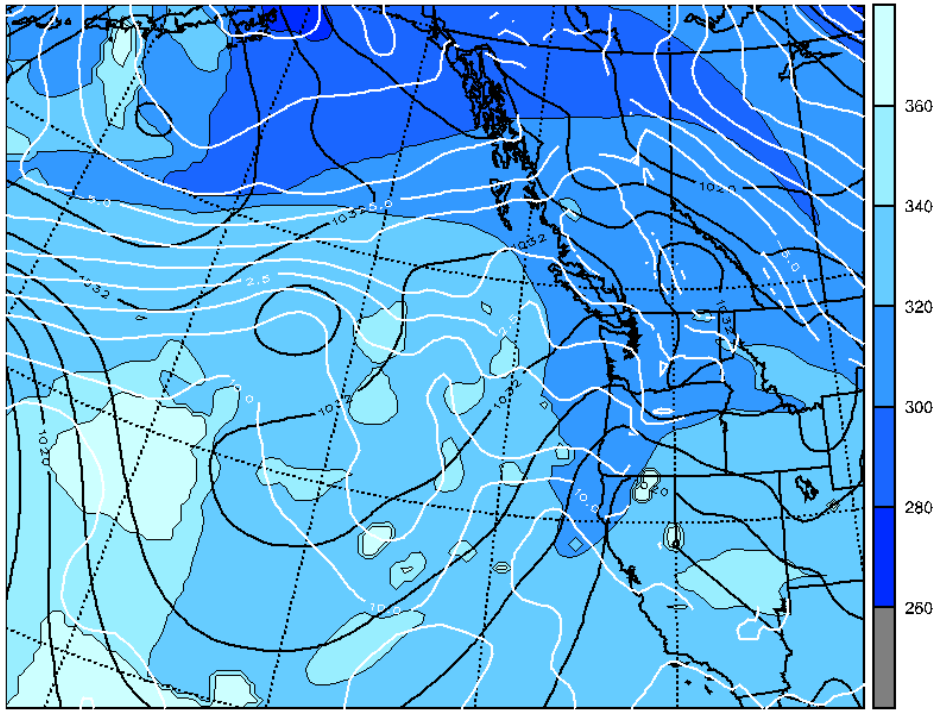
Initial Conditions: Case 1

Cold Subset



T=0 hr

Warm Subset

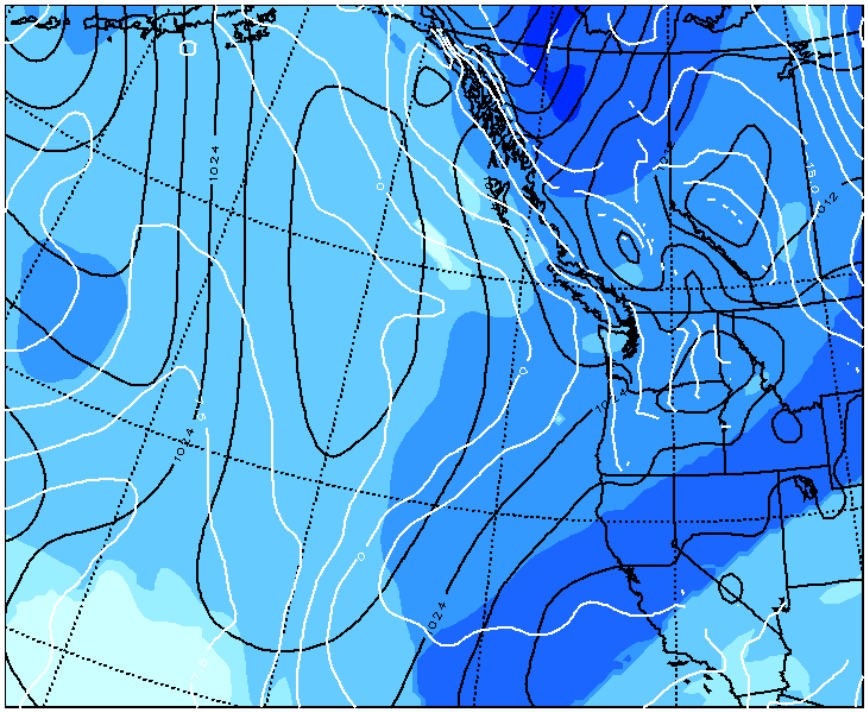


T=0 hr

Color Fill: θ on tropopause (2 PVU); Contours: 850 hPa temperature (White), SLP (Black)

Initial Conditions: Case 2

Cold Subset



T=0 hr

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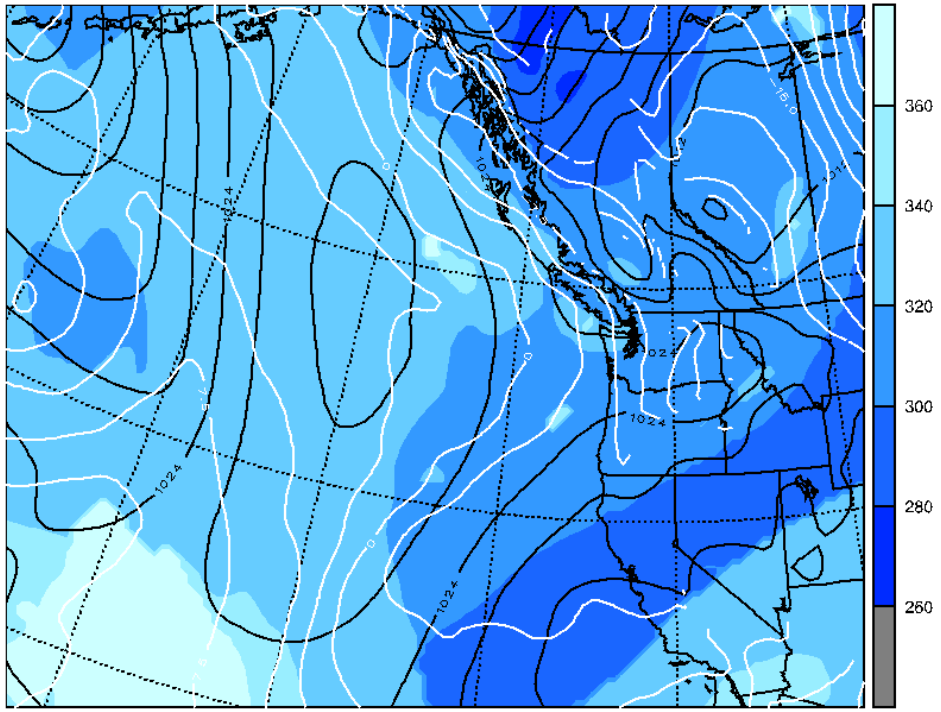

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